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Hydrologic Engineering Center

PROCEEDINGS OF A

Hydrology & Hydraulics Workshop

on

Risk-Based Analysis for Flood Damage Reduction Studies

SP-28

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FOREWORD

The Hydraulics and Hydrology Branch, HQUSACE, and the Corps Hydrology Committee cosponsored a workshop on *Risk-based Analysis for Flood Damage Reduction Studies*. The workshop was held on 20-22 October 1997 at the Asilomar Conference Center in Pacific Grove, CA. The Hydrologic Engineering Center (HEC) was responsible for the technical program and workshop coordination.

Policy issues, case example applications of procedures, a risk-based analysis computer program, and levee certification criteria for regulatory floodplain management actions were covered in the sessions. The 21 participants presented 13 technical and six panel discussion topic papers. Corps participants included representatives from Headquarters, Divisions, Districts, the Institute for Water Resources, and the Hydrologic Engineering Center. Non-corps participants were from the Sacramento Area Flood Control Agency, the Federal Emergency Management Agency, the Association of State Flood Plain Managers, Michigan State University, and the private sector.

The workshop provided a forum for exchange of ideas and perspectives on ongoing risk-based analysis for flood damage reduction studies. It also provided an opportunity to assess the progress made since the Monticello, MN. *Riverine Levee Freeboard* workshop, held in 1991, that is considered the forum that initiated risk-based analysis procedures for flood damage studies in the Corps. The primary objectives of the Asilomar workshop were to: 1) review the present policy and procedures for performing risk-based analysis studies; 2) identify key issues and discuss their means of resolution; and 3) define and discuss Corps procedures and requirements for levee analysis.

RISK-BASED ANALYSIS for FLOOD DAMAGE REDUCTION STUDIES

EXECUTIVE SUMMARY

INTRODUCTION

A workshop on *Risk-based Analysis for Flood Damage Reduction Studies* was held on 20-22 October 1997 at the Asilomar Conference Center in Pacific Grove, CA. Policy issues, case example applications of procedures, a risk-based analysis computer program, and levee certification criteria for regulatory floodplain management actions were covered in the sessions. The workshop provided a forum for exchange of ideas and perspectives on ongoing risk-based analysis for flood damage reduction studies. It also provided an opportunity to assess the progress made since the Monticello, MN. *Riverine Levee Freeboard* workshop, held in 1991. The objectives of the workshop were to: 1) review the present policy and procedures for performing risk-based analysis studies; 2) identify key issues and discuss their means of resolution; and 3) define and discuss Corps procedures and requirements for levee certification. The workshop proceedings are contained herein.

BACKGROUND

The Corps of Engineers applies risk-based analysis procedures in formulating and evaluating flood damage reduction measures. The procedures address the requirement of the Office of Management and Budget (OMB) to meet the 1982 *Principles and Guidelines* standard for federal agencies to apply risk and uncertainty procedures in the evaluation of water resources projects. Federal funding for implementing the Corps flood damage reduction project/proposals are now developed by applying risk-based analysis procedures.

The Corps policy and analytical methods for incorporating risk-based analysis in flood damage reduction studies were largely the offspring of the *Riverine Levee Freeboard* workshop held in Monticello, Minnesota in 1991. Though focused on levee sizing, freeboard concepts, and certification issues regarding Federal Emergency Management Agency's flood insurance regulatory policy, the results of the workshop were soon broadened to include the full complement of flood damage reduction measures and actions. Policy actions followed including a draft Engineering Circular 1105-2-205 in 1992 entitled *Risk-Based Analysis for Evaluation of Hydrology/Hydraulics and Economics in Flood Damage Reduction Studies* which was finalized in 1994 and upgraded to ER 1105-2-101 in 1996. Guidance was developed and presented in Engineering Manual 1110-2-1619, *Risk-Based Analysis for Flood Damage Reduction Studies*, dated 1996.

The use of risk-based analysis quantifies uncertainty in discharge-exceedance probability, stage-discharge, damage-stage relationships and incorporates it into economic and performance analyses of alternatives. The process applies Monte Carlo simulation, a numerical-analysis procedure that computes the expected value of damage reduced while explicitly accounting for the uncertainty in the basic functions. A spreadsheet application risk-based method was presented in the 1991 workshop and afterwards was slightly modified and applied to Corps studies. Its capabilities were replaced by modern, comprehensive program released in provisional form in January of 1997. The adopted risk-based analysis procedures have undergone extensive peer review including a detailed review by the National Research Council of the National Academy of Sciences.

From 1991 through 1997 over 1300 Corps personnel have been taught the risk-based concepts in the Corps formal Prospect training courses, local workshops, seminars, and technical assistance studies. During this period over 200 studies using risk-based analysis are either underway or have been completed. They range from small project continuing authorities to major urban and watershed studies. Within this span of six years the procedures have become fully integrated into the Corps technical studies and accepted as the normal way to do business.

POLICY AND PRESENT STATUS

The initial session of the workshop focused on the evolution, present policy, and status of implementing risk-based analysis as briefly chronicled above. The Corps' risk-based analysis research and development effort and overview of the broad-scaled implementation for various study purposes were presented. The goal is to develop and apply procedures that are explicitly integrated into the formulation and evaluation process so that better engineering, environmental, and economic decisions are made. Ongoing efforts and concepts involving dam safety, major project rehabilitation, flood damage reduction, and special applications and future roles in coastal areas and navigation are overviewed.

Risk-based analysis for flood damage reduction studies provides information regarding economic investments and hydraulic project performance not previously available. It is not intended to be a substitute for good engineering. Risk-based analysis is in the formulation of the type and size of plans that meet the study objectives. The locally preferred and National Economic Development (NED) plans must be identified from the final array of alternatives. They may or may not be selected as the recommended plan. A key point made during the workshop is that the formulation process must define the residual risk associated with the plans to determine the consequences of the project capacity being exceeded. The question is not if, but when the capacity is exceeded. It should include the risk to life and economic losses. The workshop participants identified residual risk as an area needing more research and definition.

The Washington Level Review staff has approved over 30 flood damage reduction feasibility-phase reports. While study checkpoint conferences have generally shown a good technical understanding of the risk-based concepts, the adopted analysis procedures and results

need to be better described and displayed in the reporting documents. Many district technical problems attributed to application of the risk-based procedures are instead ones involving the conventional plan formulation process.

PROJECT AND SPECIAL TOPIC STUDIES

Case example applications studies, geotechnical analysis for levees, communication of flood risk, special topics, and a computer program for performing the risk-based studies were covered in sessions under Project Studies. The case studies emphasized leveed major urban damage center, one of which with a major flood control reservoir immediately upstream, and urban areas involving a mix of flood damage reduction measures of levees, walls, channels and detention.

The American River Study, involving the City of Sacramento and vicinity area, was presented both from the Corps and local sponsor perspectives. Sacramento is one of the most threatened areas in the country. Approximately 400,000 people and \$37 billion in property are behind by levees. Risked-based analysis was applied to analyze the uncertainty in the upstream Folsom reservoir operation, downstream conveyance, and existing levee system. The analysis enabled development of better information on risk and project performance than would be available without the risk-based methods.

The Des Plaines River study, in metropolitan Chicago, applied risked-based methods to define uncertainty in exceedance probability, stage, and damage to formulate a system of detention reservoirs and levees. A detailed presentation of the analysis and results are presented. The St. Paul and Louisville District's experiences involving a series of studies were shared during the sessions.

The communication of flood risk was identified throughout the workshop as the single- most area needing attention and additional work. A case study was presented to describe risk communication lessons learned during public participation forums and the testing of the level of understanding of local officials and the public during the conduct of the American River Study. Better communication terms and means are needed at all levels including the internal Corps technical and managerial staffs and between the Corps and local sponsors, government officials, and the public. Better communication between the Corps and others in the profession was identified by the non-Corps participants as needed. The Corps methods are likely to be adopted by others outside the Corps and can influence a variety of actions, standards, and regulations. They expressed the need for accepted peer review within the profession and to find effective means of transferring the concepts and methods to the engineering profession as a whole.

The Hydrologic Engineering Center Flood Damage Analysis (HEC-FDA) computer program for formulating and evaluating flood damage reduction plans using risk-based analysis methods was demonstrated. The program is being used throughout the Corps. It replaces the spreadsheet software initially developed in 1991. Other special topics were covered in a panel discussion. They covered a variety of topics from the headquarters, division and district perspectives.

FLOOD PLAIN MANAGEMENT

This session explored the relationship of risk-based analysis and flood plain management. It covered issues related to flood risk data, flood plain delineation, FEMA certification, and Corps flood damage reduction project studies. Comparisons of previous approaches and risk-based analysis methods for defining project performance were covered. The procedures and criteria for FEMA for levee certification under the risk-based analysis approach were presented. The criteria and consequences of implementation of risk-based analysis for levee certification from the FEMA, Corps, the Association of Flood Plain Managers, and the private sector perspective were presented.

SUMMARY AND CONCLUSIONS

The workshop presented a variety of papers and presentations covering a range of topics within the framework of the flood damage reduction analysis using risk-based analysis procedures. The major conclusions of the workshop are listed below.

- Significant progress in incorporating and applying risk-based analysis for flood damage reduction measures has been made since the concepts were first presented for levees in the 1991 *Riverine Levee Freeboard Workshop*, held in Monticello, Minnesota. Policy and procedural documents have been prepared, applications software developed and distributed, and numerous studies formulated and evaluated. Over 1300 Corps personnel have been trained as the procedures have now been fully integrated within the Corps organization.
- Levees and floodwalls remain an important alternative for reducing flood damage in many locations. The 1991 workshop raised several issues associated with levees including: how to deal with the concept of freeboard for new, existing, and small levees; what type of analyses are required; how to better present levee performance information to local sponsors and others; and how will eliminating the concept of freeboard effect the FEMA administration of the National Flood Insurance Program regarding levee certification? Each of these issues have been successfully addressed by development and implementation of risk-based analysis policies, analytical procedures, and computer software. The concept of freeboard has been eliminated, methods of defining uncertainty in exceedance probability, stage, damage and levee geotechnical failures are incorporated into the analysis process, and better information on economic and hydraulic project performance are now generated. Finally, the FEMA levee certification process has been updated to include risk-based analysis concepts.
- Several areas of needed enhancements to the risk-based analysis capabilities were identified. These include project cost functions with uncertainty, nonstructural measures, uncertainties for specific hydraulic adjuncts (ice, debris, bulking, etc.) to the rating function, and GIS interfaces. Output should be expanded to develop more

economic related information such as number of structures flooded by zones, population impacted, etc. These additional capabilities will be considered for inclusion in future releases of the HEC-FDA program.

- Throughout the workshop, the participants expounded on the need for clearer and better flood risk communication terms and procedures. The terms and procedures may vary in scope and detail for technical analysts and the general public dissemination. One goal could be to adopt universal terminology as agreed to by an established committee of government agency, professional society, and private sector personnel.